(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 September 2002 (26.09.2002)

PCT

(10) International Publication Number
WO 02/076017 A2

(51) International Patent Classification[7]: H04L 12/00

(21) International Application Number: PCT/GB02/01091

(22) International Filing Date: 11 March 2002 (11.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0106919.4 20 March 2001 (20.03.2001) GB

(71) Applicant *(for all designated States except US)*: **MARCONI COMMUNICATIONS LIMITED** [GB/GB]; New Century Park, P.O. Box 53, Coventry CV3 1HJ (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HARDY, William, Geoffrey** [GB/GB]; 87 Monks Road, Binley Woods, Coventry CV3 3BQ (GB). **GRANDI, Vittoriano** [GB/GB]; 31 Station Avenue, Tile Hill, Coventry CV4 9HR (GB).

(74) Agent: **COLLIER, Ian, Terry**; Marconi Intellectual Property, Marrable House, The Vineyards, Great Baddow, Chelmsford, Essex CM2 7QS (GB).

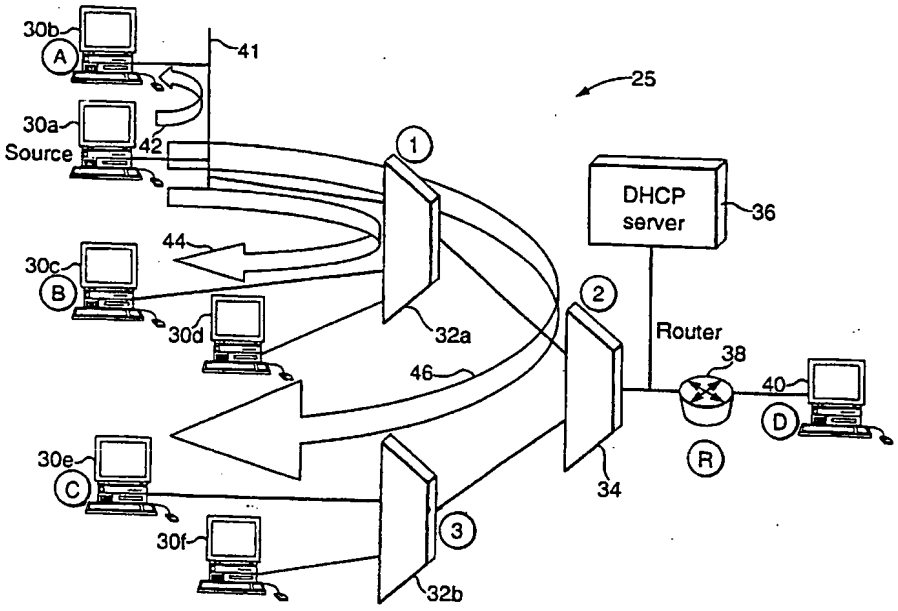
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) Title: ACCESS NETWORKS



(57) Abstract: An access network is built using Ethernet or IEEE 802.3 technology. The network comprises a plurality of terminals, a hierarchy of concentrator stages and a DHCP server. On startup of the terminals, DHCP discover messages are sent to the server which include the terminals' MAC addresses. These addresses are cached at the concentrators against the ports on which they are received. Thus unknown MAC addresses are only sent upstream. To avoid the network being flooded with broadcast messages any time a client PC uses ARP to find the MAC address of any other client, the central server provides a proxy ARP function.

WO 02/076017 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ACCESS NETWORKS

This invention relates to access networks for delivering data from telecommunications exchanges to customer premises.

Traditionally, telecommunications service providers have been required to supply voice communications to customers. More recently a variety of IP services have become available such as voice over IP, video, Internet access etc. This has caused a reevaluation of how access networks are designed.

Many businesses which are served by telecommunications companies use computer networks based on Ethernet or IEEE 802.3 standards. We have appreciated that it would be desirable to build an access network based on these standards.

We have also appreciated that such a solution would need to overcome a number of different problems caused by the differences in characteristics between access networks and ethernet/IEEE 802.3 networks. Figures 1a) and 1b) illustrate, respectively, typical ethernet/IEEE 802.3 and access networks. The former, used in a business environment, operates with a fairly random flow of traffic around the network between the various nodes. In the simple example shown, there are two nodes 10, 12 to each of which are connected a number of clients 14 and a server 16, the nodes being interconnected. The random traffic may be between the clients and the servers and will be spread throughout the network. The access network of figure 1b) comprises a number of servers 20 connected to a head end concentrator node 22 which is connected to a pair of further concentrator nodes 24, each of which is connected to a number of clients 26. Nearly all the traffic will flow from

the clients to the head end node which is the connection point to the service network and vice versa.

The lengths between nodes in a business network are typically short. As a result, it is relatively cheap to install high bandwidth links. By contrast, in an access network, clients are spread over a geographically wide area and many of the links will use low bandwidth technologies such as DSL or modem links. Moreover, an access network is typically many times larger than a business network.

Ethernet/IEEE802.3 switches rely on the use of broadcasts to find a host whose location is unknown. This is unacceptable in an access network, which is much larger than a business network as broadcast traffic would travel fruitlessly along all paths in the network using up a large amount of bandwidth in an environment in which bandwidth resources are sparse.

The aim of the present invention is to overcome the problems outlined above. Accordingly, there is provided

A method of routing data in an access network, the network comprising a server, at least one concentrator coupled to the server, and a plurality of terminals coupled to the concentrator, the method comprising: sending a unique address for each terminal from the terminal to the server via the concentrator, storing the unique terminal address at the concentrator; and routing future data addressed to a given terminal to the address for that terminal stored at the concentrator.

The invention also provides an access network, comprising a server, at least one concentrator coupled to the server, and a plurality of terminals coupled to the concentrator, wherein each of the terminal comprises means for sending a unique address for that terminal to the server via the concentrator, and the concentrator includes a store for storing the unique terminal addresses, whereby the concentrator can route future data addressed to a given terminal to the address for that terminal stored in the store.

Embodiments of the invention have the advantage that by caching terminal addresses at the concentrators, there is no need to broadcast frames on all ports when a destination address is unknown as the situation will not arise. This makes it realisable to build access networks using Ethernet/IEEE 802.3 technology.

Preferably, the server is a DHCP server and the unique address is the terminal MAC address sent in a DHCP discover message.

Preferably, the concentrators store terminal addresses against the ports on which they were received.

Preferably, where the IP address of a terminal is known but the MAC address is not, an ARP request is sent to the server. As the server already knows all the MAC addresses it can either answer the ARP request itself or send it as a unicast to the appropriate destination. This has the advantage of avoiding broadcasting ARP requests throughout the network which can flood the network and degrade performance.

An embodiment of the invention will now be described, by way of example, and with reference to the accompanying drawings in which:

Figures 1a) and 1b), referred to previously, show examples of typical business networks and access networks, respectively; and

Figure 2 shows an access network embodying the present invention.

In the access network 25 of Figure 2, a nominal number of PCs 30a-30f are connected to one of two concentrators 32a, 32b. Although PCs are used in this example, it will be appreciated that other ethernet devices could be used. The two concentrators are connected to a further concentrator 34 which is attached to a DHCP (Dynamic Host Configuration Protocol) server 36 and a router 38. The router is connected to a further PC 40 although this may not be directly connected. PCs 30a, 30b are on the same local area network (LAN).

When a source PC, for example PC 30a, wants to send an ethernet frame to another PC, the most desirable frame routing will depend on the position of the destination PC in the network.

To communicate with the PC 30b, which is on the same LAN 41, the routing will be over the LAN without the frame being sent to the access network at all. This is indicated by arrow 42 in Figure 2. In practice, if the LAN uses an ethernet switch, the frame can be maintained within the LAN. However, if a simple ethernet hub is used instead, the frame will appear at concentrator 32a). The frame should not be propagated any further throughout the access network.

Where the source PC 30a wants to send a frame to PC 30c, the ideal route is to send the frame to the port on concentrator 32a to which PC30c is connected but to no other port. Thus, the message is to be a unicast. This route is shown by an arrow 44.

Where the frame is to be sent from the source PC 30a to PC30e, the most desirable route is via the first concentrator 32a, then to the second concentrator 34 and then to the third concentrator 32b) which routes it to the port to which PC 30e is connected. None of the concentrators should route frames to any other port.

Finally, where the source PC wants to send frames to PC 40, the frames have to exit the local network and are sent to the first concentrator 32a, to the second concentrator 34 and then to PC40 via one or more routers 38 using an IP transmission protocol.

Thus, in each of the routing scenarios illustrated, if the destination address of the PC is not known it is not acceptable to broadcast to all other PCs. The routing environment is unicast. Frame transmission rules for upstream and downstream transmission for each of the concentration points may be summarised as follows:

<u>Upstream Frames</u>

If the destination MAC (Media Access Control) address of the frame is known to be downstream of any concentrator output port, send the frame to that port, unless the frame was received on that port, and no other; else send the frame upstream to the next concentration point.

Downstream Frames

If the destination MAC address of the frame is known to be downstream of any output port, then send the frame to that port and no other, else discard the frame.

A conventional ethernet switch could obey both the upstream and downstream conditions where the destination address is known, but would not obey the rules if the address was not known, resorting to a network broadcast asking the destination to identify itself. This problem is solved by maintaining a record of the identities of all PCs on the network at an upstream location. In an access network, it is essential that each concentration stage knows all the MAC addresses of the PCs that are downstream of its ports. Unlike a conventional LAN, a client cannot be spoken to until it has spoken itself.

This is achieved in the Figure 2 embodiment by using the DHCP requests to the DHCP server 36 to create the association between terminal and address within the concentrator. On start up of the PC, as it boots up, the PC will send a DHCP discover message containing its MAC address. These MAC addresses are received at the concentrators, cached and stored against the port from which they have been received before being sent on to the DHCP server.

Thus, the ethernet concentrators each has an address table which stores a record of its various port numbers and the address of each PC connected to those ports. Concentrators will often age out entries in address tables. In order to prevent this from becoming a problem, the DHCP lease timeout can be set to a time less than the

concentrator age timeout. Thus, clients that are active on the Internet will refresh their MAC addresses when they renew their DHCP leases.

The following section considers how the MAC address of a client can be determined if the IP address for the client is already known. In this situation an ARP (Address Resolution Protocol) message is conventionally sent. This protocol uses a broadcast message to identify itself. In an access network, this behaviour is undesirable.

If used in the conventional manner in an access network the network would be flooded with broadcast messages as any time a client PC used ARP to find the MAC address of any other client, a broadcast would be sent to all other clients. This would degrade performance in a limited bandwidth network such as an access network.

This problem may be eliminated by using an ARP proxy function within the DHCP server or Head End Concentrator 34. The concentrators forward all broadcasts upstream, rather than sending them back both upstream and downstream to all connected ports. The ARP proxy function, which has a stored list of the MAC addresses of all clients, will then respond on behalf of the client.

Alternatively, the ARP proxy function can receive the ARP request, look up the MAC address for the intended recipient and forward the ARP request to that recipient. This is a unicast rather than a broadcast downstream. The client then responds to the original requester in the normal manner. This method will only work if the client's software will accept a unicast ARP request.

Thus, in the system and method described, broadcast frames are only sent upstream and never transmitted downstream.

It will be appreciated from the foregoing description that the embodiment enables an ethernet/IEEE 802.3 network to be used in an access network. This is advantageous as many of the customers connected to the access network will already be using this type of network.

Various modifications to the embodiment described are possible within the scope of the invention and will occur to those skilled in the art. The invention is defined by the following claims:

Claims

1. A method of routing data in an access network, the network comprising a server, at least one concentrator coupled to the server, and a plurality of terminals coupled to the concentrator, the method comprising:

sending a unique address for each terminal from the terminal to the server via the concentrator,

storing the unique terminal address at the concentrator; and

routing future data addressed to a given terminal to the address for that terminal stored at the concentrator.

2. A method according to claim 1, wherein the step of sending a unique address comprises sending the MAC address of each terminal.

3. A method according to claim 1 or 2, wherein the server is a DHCP server and the step of sending a unique address to the server comprises sending a DHCP discover message to the server, the DHCP discover message containing the unique address.

4. A method according to any of the claims 1 to 3, wherein the step of storing the unique terminal addresses at the concentrator comprises storing the terminal addresses against the port of the concentrator from which they are received.

5. A method according to any of claims 1 to 4, wherein each of the terminals, the server and the concentrator have a timeout period for stored entries, comprising setting the timeout of the terminals addresses to a timeout shorter than that of the concentrator store or the serve.

6. A method according to any of claims 1 to 5, comprising sending an address resolution protocol (ARP) broadcast message from a terminal to thee concentrator and routing the ARP broadcast message to the server.

7. A method according to claim 6, wherein the server sends out the unique address of a terminal identified in the ARP request to the requesting terminal.

8. A method according to claim 6, wherein the server forwards the ARP request as a unicast message to the unique address of the terminal identified in the ARP request.

9. An access network, comprising a server, at least one concentrator coupled to the server, and a plurality of terminals coupled to the concentrator, wherein each of the terminal comprise means for sending a unique address for that terminal to the server via the concentrator, and the concentrator includes a store for storing the unique terminal addresses, whereby the concentrator can route future data addressed to a given terminal to the address for that terminal stored in the store.

10. An access network according to claim 9, wherein the unique address sending means at each terminal comprises means for sending the MAC address of that terminal.

11. An access network according to claim 9 or 10, wherein the server is a DHCP server and the means for sending a unique address to the DHCP server at each terminal comprises means for sending a DHCP discover message to the DHCP server, the DHCP discover message contains the unique address.

12. An access network according to any of the claims 9 to 11, wherein the concentrator store stores the unique

terminal addresses against the ports on which they were received from the terminals.

13. An access network according to any of the claims 9 to 12, wherein each of the terminals, the server and the concentrator store includes a timeout for stored entries, where the timeout of the terminals is set to a time shorter than the timeout of the server or the concentrator store.

14. An access network according to any of the claims 9 to 13, wherein the terminals include means for broadcasting an ARP message to the server via the concentrator.

15. An access network according to claim 14, wherein the server comprises means for sending out the unique address of a terminal identified in the ARP request to the requesting terminal.

16. An access network according to claim 14, wherein the server comprises means for routing the ARP request to terminal identified in the ARP request.

17. An access network according to any of claims 9 to 16, wherein the network is an Ethernet or IEEE 802.3 network.

18. An access network according to any of claims 9 to 17, wherein the network comprises a plurality of concentrators arranged between the server and the terminals, a first concentrator being connected between the server and further concentrators, and the further concentrators being connected either to the terminals or indirectly to the terminals via one or more further concentrators.

Fig.1b.
Access Network

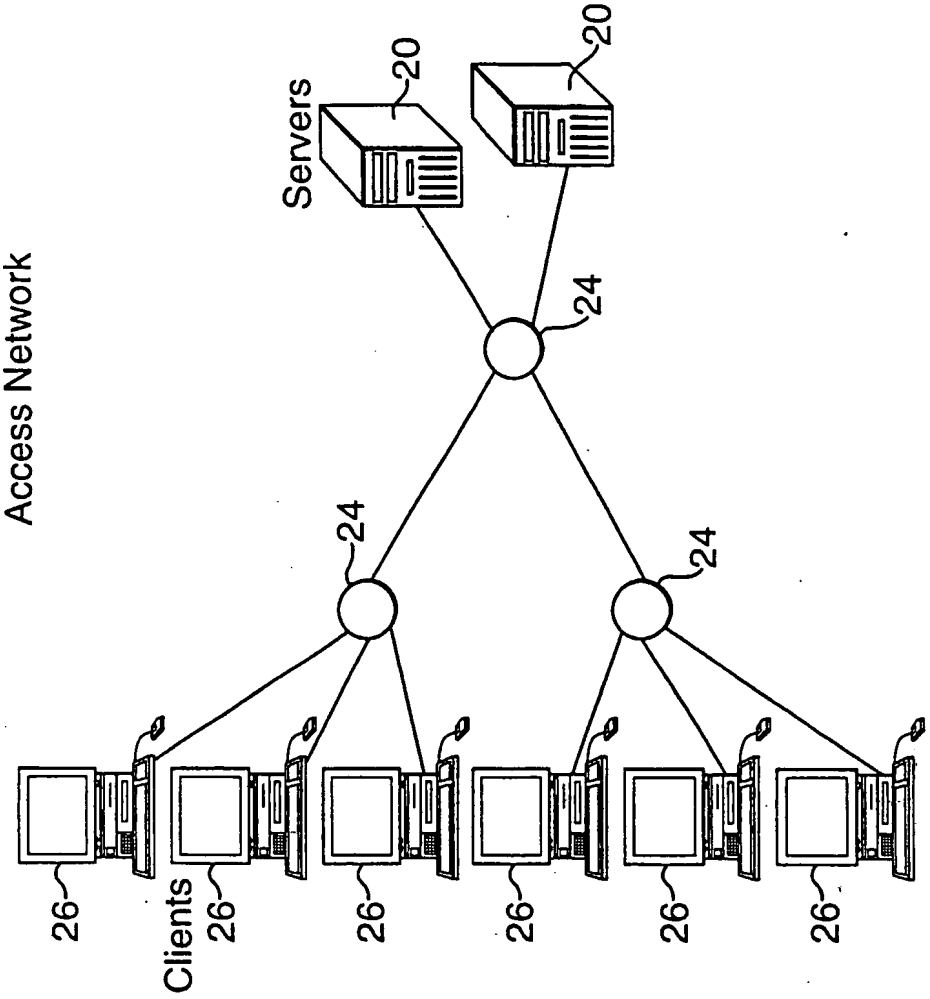


Fig.1a.
Business Network

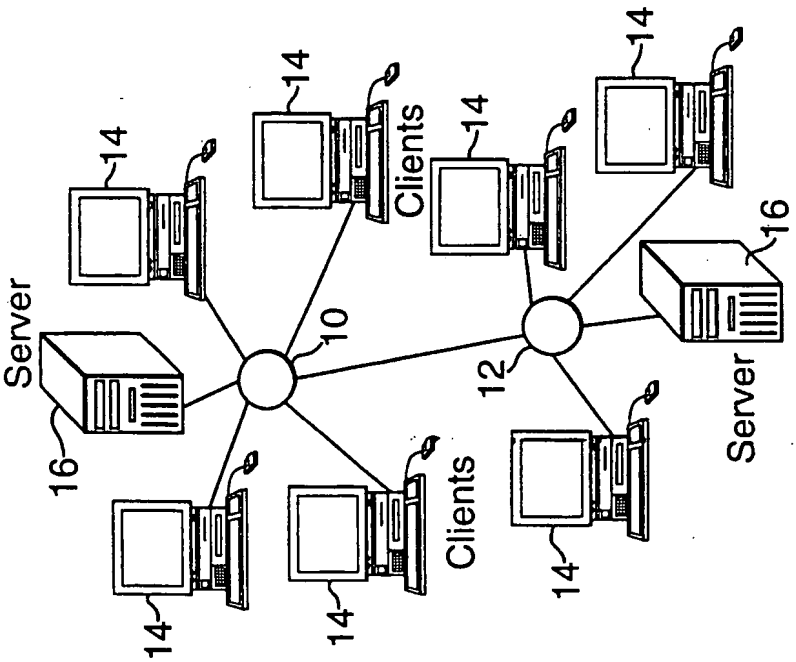
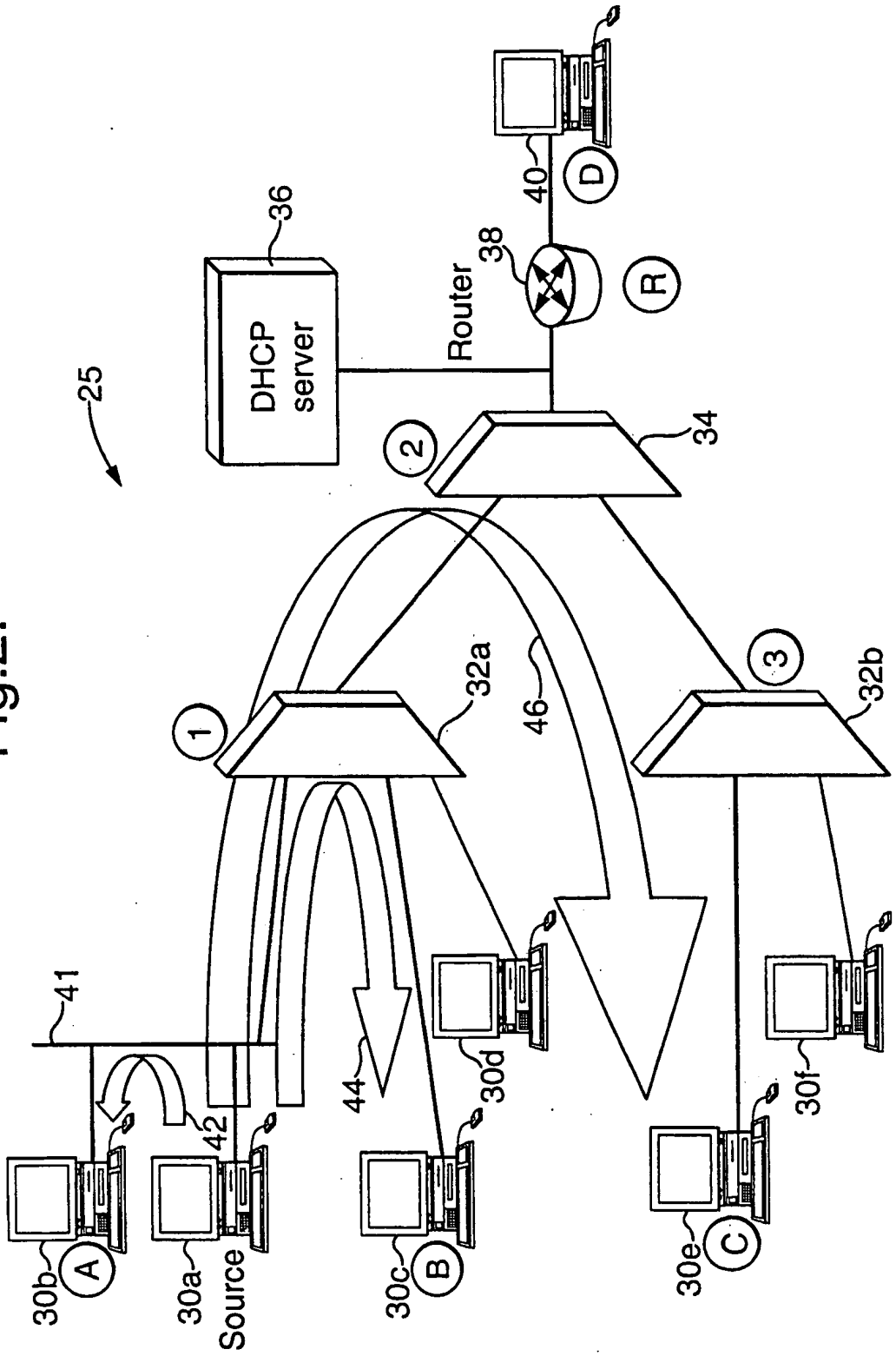


Fig.2.


25
DHCP server
36
Router
38
R
40
D
2
34
1
32a
46
3
32b
41
44
42
30d
30f
30b
A
30a
Source
30c
B
30e
C

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 September 2002 (26.09.2002)

PCT

(10) International Publication Number
WO 02/076017 A3

(51) International Patent Classification[7]: H04L 29/12, 12/28

(21) International Application Number: PCT/GB02/01091

(22) International Filing Date: 11 March 2002 (11.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0106919.4 20 March 2001 (20.03.2001) GB

(71) Applicant *(for all designated States except US)*: **MARCONI COMMUNICATIONS LIMITED** [GB/GB]; New Century Park, P.O. Box 53, Coventry CV3 1HJ (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HARDY, William, Geoffrey** [GB/GB]; 87 Monks Road, Binley Woods, Coventry CV3 3BQ (GB). **GRANDI, Vittoriano** [GB/GB]; 31 Station Avenue, Tile Hill, Coventry CV4 9HR (GB).

(74) Agent: **COLLIER, Ian, Terry**; Marconi Intellectual Property, Marrable House, The Vineyards, Great Baddow, Chelmsford, Essex CM2 7QS (GB).

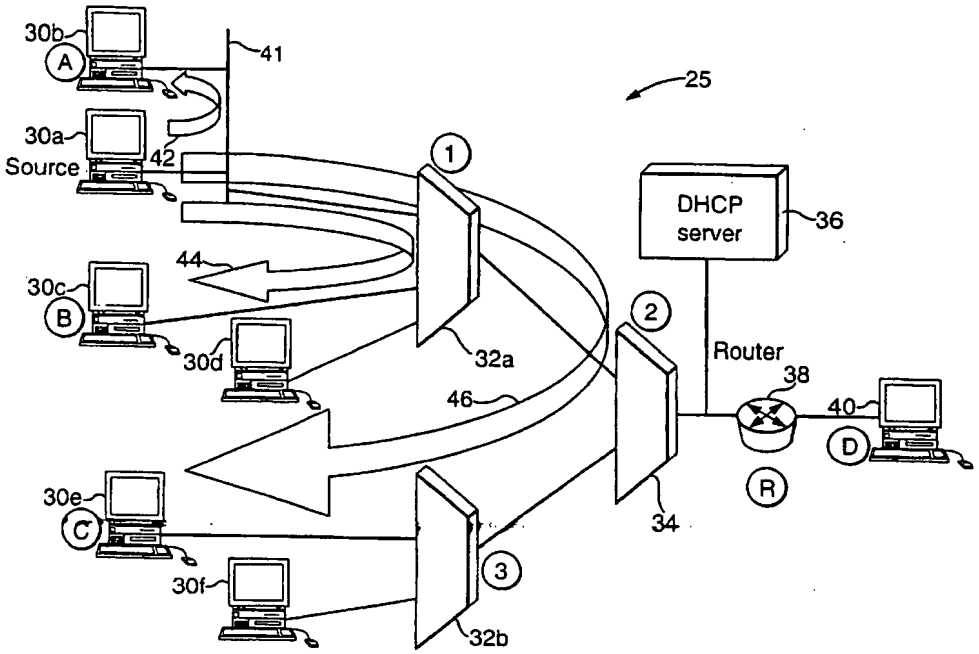
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

[Continued on next page]

(54) Title: ACCESS NETWORKS



(57) Abstract: An access network is built using Ethernet or IEEE 802.3 technology. The network comprises a plurality of terminals, a hierarchy of concentrator stages and a DHCP server. On startup of the terminals, DHCP discover messages are sent to the server which include the terminals' MAC addresses. These addresses are cached at the concentrators against the ports on which they are received. Thus unknown MAC addresses are only sent upstream. To avoid the network being flooded with broadcast messages any time a client PC uses ARP to find the MAC address of any other client, the central server provides a proxy ARP function.

WO 02/076017 A3

(88) Date of publication of the international search report:
10 April 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/12 H04L12/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00 79733 A (AT & T WIRELESS SERVICES INC) 28 December 2000 (2000-12-28) abstract	1-3, 5-11, 13-16,18
Y	page 4, line 24 -page 5, line 9 page 8, line 1 -page 9, line 27 page 13, line 6 -page 14, line 15 page 15, line 25 -page 23, line 124	4,12,17
Y	EP 0 998 081 A (HEWLETT PACKARD CO) 3 May 2000 (2000-05-03) abstract page 2, column 2, line 36 -page 3, column 3, line 7 page 8, column 14, line 50 -page 9, column 15, line 1 page 9, column 15, line 50 -column 16, line 26	4,12,17

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 January 2003	17/01/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Karavassilis, N

Form PCT/ISA/210 (second sheet) (July 1992)

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0079733 A	28-12-2000	WO 0079733 A2	28-12-2000
		WO 0079765 A1	28-12-2000
		US 2002165972 A1	07-11-2002
EP 0998081 A	03-05-2000	EP 0998081 A1	03-05-2000
		JP 2000261505 A	22-09-2000

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 September 2002 (26.09.2002)

PCT

(10) International Publication Number
WO 02/076017 A3

(51) International Patent Classification[7]: H04L 29/12, 12/28

(21) International Application Number: PCT/GB02/01091

(22) International Filing Date: 11 March 2002 (11.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0106919.4 20 March 2001 (20.03.2001) GB

(71) Applicant *(for all designated States except US)*: **MARCONI COMMUNICATIONS LIMITED** [GB/GB]; New Century Park, P.O. Box 53, Coventry CV3 1HJ (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HARDY, William, Geoffrey** [GB/GB]; 87 Monks Road, Binley Woods, Coventry CV3 3BQ (GB). **GRANDI, Vittoriano** [GB/GB]; 31 Station Avenue, Tile Hill, Coventry CV4 9HR (GB).

(74) Agent: **COLLIER, Ian, Terry**; Marconi Intellectual Property, Marrable House, The Vineyards, Great Baddow, Chelmsford, Essex CM2 7QS (GB).

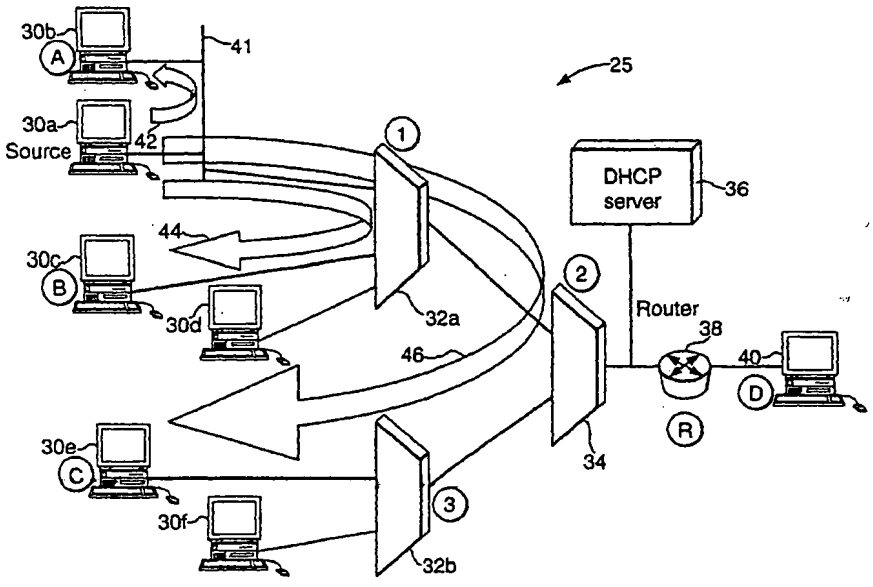
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

[Continued on next page]

(54) Title: ACCESS NETWORKS



(57) Abstract: An access network is built using Ethernet or IEEE 802.3 technology. The network comprises a plurality of terminals, a hierarchy of concentrator stages and a DHCP server. On startup of the terminals, DHCP discover messages are sent to the server which include the terminals' MAC addresses. These addresses are cached at the concentrators against the ports on which they are received. Thus unknown MAC addresses are only sent upstream. To avoid the network being flooded with broadcast messages any time a client PC uses ARP to find the MAC address of any other client, the central server provides a proxy ARP function.

WO 02/076017 A3

(88) Date of publication of the international search report: 10 April 2003

Date of publication of the amended claims: 19 June 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AMENDED CLAIMS

[Received by the International Bureau on 06 March 2003 (06.03.03): original claims 1-18 replaced by amended/new claims 1-24; (4 pages)]

1. A method of routing data in an access network, the network comprising a server, at least one concentrator coupled to the server via an upstream port of the concentrator, and a plurality of terminals coupled to the concentrator via at least one downstream port of the concentrator, the method comprising:

sending a unique address for each terminal from the terminal to the server via the concentrator,

storing the unique terminal address at the concentrator; and

routing future data addressed to a given destination terminal according to the address for that terminal stored at the concentrator;

if the destination of the data is connected via a downstream port, sending the data to that port, and no other.

2. A method according to claim 1 including the step of, if the data is received via a downstream port and the destination of the data is not connected via a downstream port, sending the data to the upstream port.

3. A method according to any above claim including the step of, if the data is received via the upstream port and the destination of the data is not connected via a downstream port, discarding the data.

4. A method according to any above claim in which broadcast data are only sent upstream and never downstream.

5. A method according to any above claim, wherein the step of sending a unique address comprises sending the MAC address of each terminal.

6. A method according to any above claim, wherein the server is a DHCP server and the step of sending a unique address to the server comprises sending a DHCP discover message to the server, the DHCP discover message containing the unique address.

7. A method according to any above claim, wherein the step of storing the unique terminal addresses at the concentrator comprises storing the terminal addresses against the port of the concentrator from which they are received.

8. A method according to any above claim, wherein each of the terminals, the server and the concentrator have a timeout period for stored entries, comprising setting the timeout of the terminals addresses to a timeout shorter than that of the concentrator store or the server.

9. A method according to any above claim, comprising sending an address resolution protocol (ARP) broadcast message from a terminal to the concentrator and routing the ARP broadcast message to the server.

10. A method according to claim 9, wherein the server sends out the unique address of a terminal identified in the ARP request to the requesting terminal.

11. A method according to claim 9, wherein the server forwards the ARP request as a unicast message to the unique address of the terminal identified in the ARP request.

12. An access network, comprising a server, at least one concentrator coupled to the server via an upstream port of the concentrator, and a plurality of terminals coupled to the concentrator via at least one downstream port of the

concentrator, wherein each of the terminals comprise means for sending a unique address for that terminal to the server via the concentrator, and the concentrator includes a store for storing the unique terminal addresses, in which the concentrator comprises means for sending data for which the destination is connected via a downstream port to that port and no other.

13. An access network according to claim 12 in which the concentrator comprises means for sending data received via a downstream port and for which the destination is not connected via a downstream port to the upstream port.

14. An access network according to claims 12 or 13 in which the concentrator comprises means for discarding data received via the upstream port and for which the destination is not connected via a downstream port.

15. An access network according to claims 12 to 14 in which the concentrator comprises means for sending broadcast data upstream and never downstream.

16. An access network according to claims 12 to 15, wherein the unique address sending means at each terminal comprises means for sending the MAC address of that terminal.

17. An access network according to claims 12 to 16, wherein the server is a DHCP server and the means for sending a unique address to the DHCP server at each terminal comprises means for sending a DHCP discover message to the DHCP server, the DHCP discover message contains the unique address.

18. An access network according to any of the claims 12 to 17, wherein the concentrator store stores the unique

terminal addresses against the ports on which they were received from the terminals.

19. An access network according to any of the claims 12 to 18, wherein each of the terminals, the server and the concentrator store includes a timeout for stored entries, where the timeout of the terminals is set to a time shorter than the timeout of the server or the concentrator store.

20. An access network according to any of the claims 12 to 19, wherein the terminals include means for broadcasting an ARP message to the server via the concentrator.

21. An access network according to claim 20, wherein the server comprises means for sending out the unique address of a terminal identified in the ARP request to the requesting terminal.

22. An access network according to claim 20, wherein the server comprises means for routing the ARP request to terminal identified in the ARP request.

23. An access network according to any of claims 12 to 22, wherein the network is an Ethernet or IEEE 802.3 network.

24. An access network according to any of claims 12 to 23, wherein the network comprises a plurality of concentrators arranged between the server and the terminals, a first concentrator being connected between the server and further concentrators, and the further concentrators being connected either to the terminals or indirectly to the terminals via one or more further concentrators.